

73 Circadian Rhythm is an endogenously driven cycle for biochemical, physiological and behavioral processes. In humans, the approximate duration of this 'biological clock' is:

- A. 1 Hour
- B. 6 Hours
- C. 12 Hours
- D. 24 Hours

74 Modern evolutionary theory consists of the concepts of Darwin modified by knowledge concerning:

- A. population statistics
- B. Mendel's laws
- C. the idea of the survival of the fittest
- D. competition

75 Soon after the three germ layers are formed in a developing embryo, the process of organogenesis starts. The human brain is formed from the

- A. ectoderm
- B. endoderm
- C. mesoderm
- D. partly endoderm and partly mesoderm

76 Puffs in the polytene chromosomes of *Drosophila melanogaster* salivary glands represent

- A. transcriptionally active genes
- B. transcriptionally inactive genes
- C. heterochromatin
- D. housekeeping genes

77 The process of cell death involving DNA cleavage in cells is known as

- A. necrosis
- B. apoptosis
- C. cytokinesis
- D. endocytosis

78 According to the original model of DNA, as proposed by Watson & Crick in 1953, DNA is a

- A. left handed helix
- B. helix that makes a full turn every 70 nm.
- C. helix where one turn of DNA contains 20 basepairs
- D. two stranded helix where each strand has opposite polarity.

79 At which stage of Meiosis I does crossing over occur?

- A. leptotene
- B. zygotene
- C. pachytene
- D. diplotene

80 An electrode is placed in the axoplasm of a mammalian axon and another electrode is placed just outside the axon. The potential difference measured will be

- A. 0
- B. -70 mV
- C. -70 μ V
- D. +70 μ V

Part-II (2 Marks)

MATHEMATICS

- 81 Let A and B be any two $n \times n$ matrices such that the following conditions hold: $AB = BA$ and there exist positive integers k and l such that $A^k = I$ (the identity matrix) and $B^l = O$ (the zero matrix). Then

- A. $A + B = I$
- B. $\det(AB) = 0$
- C. $\det(A + B) \neq 0$
- D. $(A + B)^m = O$ for some integer m

- 82 The minimum value of n for which

$$\frac{2^2 + 4^2 + 6^2 + \dots + (2n)^2}{1^2 + 3^2 + 5^2 + \dots + (2n-1)^2} < 1.01$$

- A. is 101
- B. is 121
- C. is 151
- D. does not exist

- 83 The locus of the point $P = (a, b)$ where a, b are real numbers such that the roots of $x^3 + ax^2 + bx + a = 0$ are in arithmetic progression is

- A. an ellipse
- B. a circle
- C. a parabola whose vertex is on the y -axis
- D. a parabola whose vertex is on the x -axis

- 84 The smallest possible positive slope of a line whose y -intercept is 5 and which has a common point with the ellipse $9x^2 + 16y^2 = 144$ is

- A. $\frac{3}{4}$
- B. 1
- C. $\frac{4}{3}$
- D. $\frac{9}{16}$

- 85 Let $A = \{\theta \in \mathbf{R} \mid \cos^2(\sin \theta) + \sin^2(\cos \theta) = 1\}$ and $B = \{\theta \in \mathbf{R} \mid \cos(\sin \theta) \sin(\cos \theta) = 0\}$. Then $A \cap B$

- A. is the empty set
- B. has exactly one element
- C. has more than one but finitely many elements
- D. has infinitely many elements

- 86 Let $f(x) = x^3 + ax^2 + bx + c$, where a, b, c are real numbers. If $f(x)$ has a local minimum at $x = 1$ and a local maximum

at $x = -\frac{1}{3}$ and $f(2) = 0$, then $\int_{-1}^1 f(x) dx$ equals

- A. $\frac{14}{3}$
- B. $-\frac{14}{3}$
- C. $\frac{7}{3}$
- D. $-\frac{7}{3}$

87 Let $f(x) = x^{12} - x^9 + x^4 - x + 1$. Which of the following is true?

- A. f is one-one
- B. f has a real root
- C. f' never vanishes
- D. f takes only positive values

88 For each positive integer n , define $f_n(x) = \text{minimum}\left(\frac{x^n}{n!}, \frac{(1-x)^n}{n!}\right)$, for $0 \leq x \leq 1$.

Let $I_n = \int_0^1 f_n(x) dx$, $n \geq 1$. Then $\sum_{n=1}^{\infty} I_n$ is equal to

- A. $2\sqrt{e} - 3$
- B. $2\sqrt{e} - 2$
- C. $2\sqrt{e} - 1$
- D. $2\sqrt{e}$

89 The maximum possible value of $x^2 + y^2 - 4x - 6y$, x, y real, subject to the condition $|x + y| + |x - y| = 4$

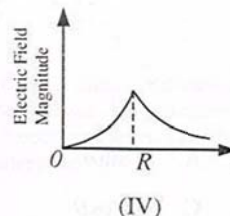
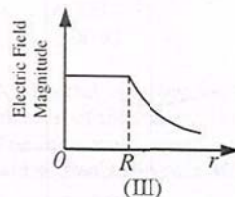
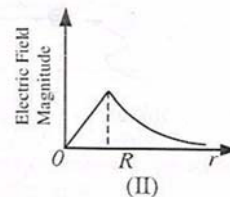
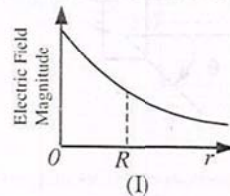
- A. is 12
- B. is 28
- C. is 72
- D. does not exist

90 The arithmetic mean and the geometric mean of two distinct 2-digit numbers x and y are two integers one of which can be obtained by reversing the digits of the other (in base 10 representation). Then $x + y$ equals

- A. 82
- B. 116
- C. 130
- D. 148

PHYSICS

91 An isolated sphere of radius R contains uniform volume distribution of positive charge. Which of the curves shown below correctly illustrates the dependence of the magnitude of the electric field of the sphere as a function of the distance r from its centre?

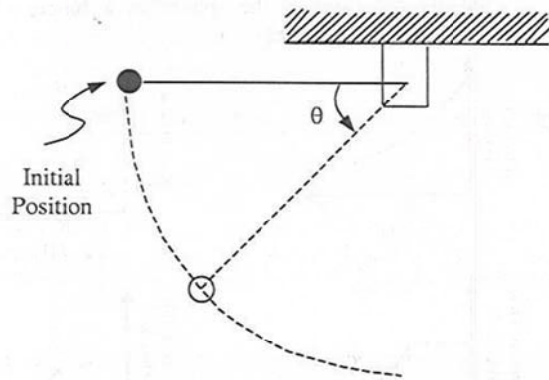


- A. I
- B. II
- C. III
- D. IV

92 The surface of a planet is found to be uniformly charged. When a particle of mass m and no charge is thrown at an angle from the surface of the planet, it has a parabolic trajectory as in projectile motion with horizontal range L . A particle of mass m and charge q , with the same initial conditions has a range $L/2$. The range of particle of mass m and charge $2q$ with the same initial conditions is

- A. L
- B. $L/2$
- C. $L/3$
- D. $L/4$

- 93 Figure below shows a small mass connected to a string, which is attached to a vertical post. If the ball is released when the string is horizontal as shown, the magnitude of the total acceleration (including radial and tangential) of the mass as a function of the angle θ is

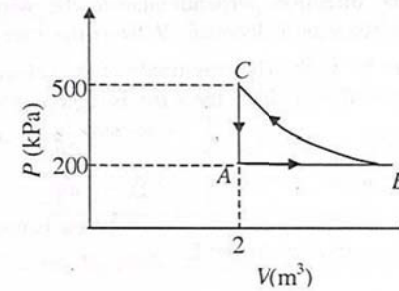


- A. $g \sin \theta$ B. $g\sqrt{3\cos^2\theta + 1}$
 C. $g \cos \theta$ D. $g\sqrt{3\sin^2\theta + 1}$

- 94 One mole of an ideal gas at initial temperature T , undergoes a quasi-static process during which the volume V is doubled. During the process the internal energy U obeys the equation $U = aV^3$, where a is a constant. The work done during this process is

- A. $3RT/2$ B. $5RT/2$
 C. $5RT/3$ D. $7RT/3$

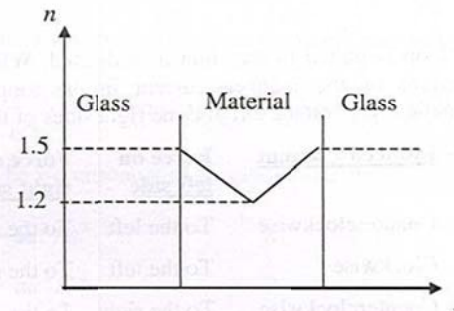
- 95 A constant amount of an ideal gas undergoes the cyclic process ABCA in the PV diagram shown below.



The path BC is an isothermal. The work done by the gas during one complete cycle, beginning and ending at A, is nearly

- A. 600 kJ B. 300 kJ
 C. -300 kJ D. -600 kJ

- 96 A material is embedded between two glass plates. Refractive index n of the material varies with thickness as shown below. The maximum incident angle (in degrees) on the material for which beam will pass through the material is

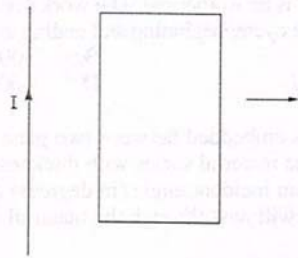


- A. 60.0 B. 53.1
 C. 43.5 D. 32.3

- 97 At a distance l from a uniformly charged long wire, a charged particle is thrown radially outward with a velocity u in the direction perpendicular to the wire. When the particle reaches a distance $2l$ from the wire its speed is found to be $\sqrt{2}u$. The magnitude of the velocity, when it is a distance $4l$ away from the wire, is (ignore gravity)

- A. $\sqrt{3}u$ B. $2u$
 C. $2\sqrt{2}u$ D. $4u$

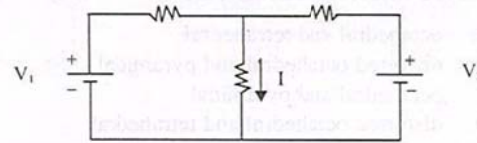
- 98 A rectangular loop of wire shown below is coplanar with a long wire carrying current I .



The loop is pulled to the right as indicated. What are the directions of the induced current in the loop and the magnetic forces on the left and the right sides of the loop?

- | | <u>Induced Current</u> | <u>Force on left side</u> | <u>Force on right side</u> |
|----|------------------------|---------------------------|----------------------------|
| A. | Counterclockwise | To the left | To the right |
| B. | Clockwise | To the left | To the right |
| C. | Counterclockwise | To the right | To the left |
| D. | Clockwise | To the right | To the left |

- 99 Two batteries V_1 and V_2 are connected to three resistors as shown below.



If $V_1 = 2\text{ V}$ and $V_2 = 0\text{ V}$, the current $I = 3\text{ mA}$. If $V_1 = 0\text{ V}$ and $V_2 = 4\text{ V}$, the current $I = 4\text{ mA}$. Now, if $V_1 = 10\text{ V}$ and $V_2 = 10\text{ V}$, the current I will be

- A. 7 mA B. 15 mA
 C. 20 mA D. 25 mA

- 100 A particle moves in a plane along an elliptic path given by

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1. \text{ At point } (0, b), \text{ the } x\text{-component of velocity}$$

is u . The y -component of acceleration at this point is

- A. $-bu^2/a^2$ B. $-u^2/b$
 C. $-au^2/b^2$ D. $-u^2/a$

CHEMISTRY

101 XeF_6 hydrolyses to give an oxide. The structures of XeF_6 and the oxide, respectively, are

- A. octahedral and tetrahedral
- B. distorted octahedral and pyramidal
- C. octahedral and pyramidal
- D. distorted octahedral and tetrahedral

102 MnO_4^- oxidizes (i) oxalate ion in acidic medium at 333 K and (ii) HCl. For balanced chemical equations, the ratios $[\text{MnO}_4^- : \text{C}_2\text{O}_4^{2-}]$ in (i) and $[\text{MnO}_4^- : \text{HCl}]$ in (ii), respectively, are

- A. 1 : 5 and 2 : 5
- B. 2 : 5 and 1 : 8
- C. 2 : 5 and 1 : 5
- D. 5 : 2 and 1 : 8

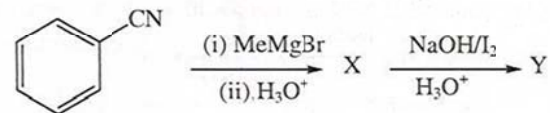
103 If $E_{\text{Fe}^{2+}/\text{Fe}}^\circ = -0.440 \text{ V}$ and $E_{\text{Fe}^{3+}/\text{Fe}^{2+}}^\circ = 0.770 \text{ V}$, then $E_{\text{Fe}^{3+}/\text{Fe}}^\circ$ is

- A. 0.330 V
- B. -0.037 V
- C. -0.330 V
- D. -1.210 V

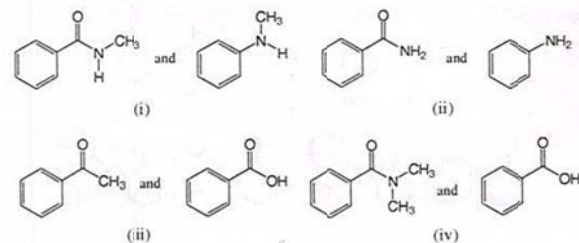
104 The electron in hydrogen atom is in the first Bohr orbit ($n = 1$). The ratio of transition energies, $E(n = 1 \rightarrow n = 3)$ to $E(n = 1 \rightarrow n = 2)$, is

- A. 32/27
- B. 16/27
- C. 32/9
- D. 8/9

105 In the following conversion,

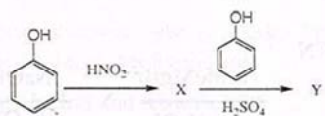


the major products X and Y, respectively, are

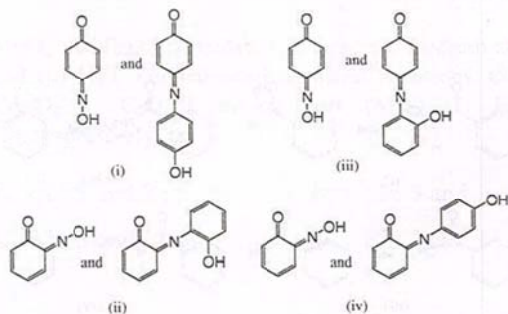


- A. i
- B. ii
- C. iii
- D. iv

106 In the reaction sequence,

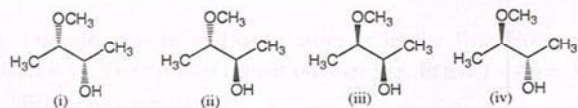


the major products X and Y, respectively, are



- A. i
C. iii
- B. ii
D. iv

107 Optically active (S)- α -methoxyacetaldehyde on reaction with MeMgX gave a mixture of alcohols. The major diastereomer 'P' on treatment with $\text{MeI/K}_2\text{CO}_3$ gave an optically inactive compound. P is



- A. i
C. iii
- B. ii
D. iv

108 At 300 K the vapour pressures of two pure liquids, A and B are 100 and 500 mm Hg, respectively. If in a mixture of A and B, the vapour pressure is 300 mm Hg, the mole fractions of A in the liquid and in the vapour phase, respectively, are

- A. 1/2 and 1/10
C. 1/4 and 1/10
- B. 1/4 and 1/6
D. 1/2 and 1/6

109 The crystal field stabilization energies (CFSE) of high spin and low spin d^6 metal complexes in terms of Δ_0 , respectively, are

- A. -0.4 and -2.4
C. -0.4 and 0.0
- B. -2.4 and -0.4
D. -2.4 and 0.0

110 Emulsification of 10 ml of oil in water produces 2.4×10^{18} droplets. If the surface tension at the oil-water interface is 0.03 Jm^{-2} and the area of each droplet is $12.5 \times 10^{-16} \text{ m}^2$, the energy spent in the formation of oil droplets is

- A. 90 J
C. 900 J
- B. 30 J
D. 10 J

BIOLOGY

- 111 Which sequence of events gives rise to flaccid guard cells and stomatal closure at night?
- A. low [Glucose] \Rightarrow low osmotic pressure \Rightarrow low pH \Rightarrow high $p\text{CO}_2$
 - B. low pH \Rightarrow high $p\text{CO}_2$ \Rightarrow low [Glucose] \Rightarrow low osmotic pressure
 - C. low osmotic pressure \Rightarrow high $p\text{CO}_2$ \Rightarrow low pH \Rightarrow low [Glucose]
 - D. high $p\text{CO}_2$ \Rightarrow low pH \Rightarrow low [Glucose] \Rightarrow low osmotic pressure
- 112 Rice has a diploid genome with $2n = 24$. If crossing-over is stopped in a rice plant and then selfed seeds are collected, will all the offsprings be genetically identical to the parent plant?
- A. yes, because crossing-over is the only source of genetic variation
 - B. no, because stopping of crossing-over automatically increases rate of point mutation
 - C. yes, only if the parent plant was a completely inbred line
 - D. yes, only if the parent plant was a hybrid between two pure-bred lines
- 113 Rodents can distinguish between many different types of odours. The basis for odour discrimination is that
- A. they have a small number of odorant receptors that bind to many different odorant molecules
 - B. the mechanoreceptors in the nasal cavity are activated by different odorant molecules found in the air passing through the nostrils
 - C. the part of the brain that processes the sense of smell has many different receptors for odorant molecules
 - D. a large number of different chemoreceptors are present in the nasal cavity that binds a variety of odorant molecules
- 114 Although blood flows through large arteries at high pressure, when the blood reaches small capillaries the pressure decreases because
- A. the valves in the arteries regulate the rate of blood flow into the capillaries
 - B. the volume of blood in the capillaries is much lesser than that in the arteries
 - C. the total cross-sectional area of capillaries arising from an artery is much greater than that of the artery
 - D. elastin fibers in the capillaries help to reduce the arterial pressure

115 *E. coli* about to replicate was pulsed with tritiated thymidine for 5 min and then transferred to normal medium. After one cell division which one of the following observations would be correct?

- A. both the strands of DNA will be radioactive
- B. one strand of DNA will be radioactive
- C. none of the strands will be radioactive
- D. half of one strand of DNA will be radioactive

116 Selection of lysine auxotroph (bacteria which requires lysine for growth) from a mixed population of bacteria can be done by growing the bacterial population in the presence of

- A. lysine
- B. penicillin
- C. lysine and penicillin
- D. glucose

117 Increasing the number of measurements of an experimental variable will

- A. increase the standard error of the sample
- B. increase the mean of the sample
- C. decrease the standard error of the sample
- D. result in all of the above

118 For a human male what is the probability that all the maternal chromosomes will end up in the same gamete?

- A. $1/23$
- B. 2^{23}
- C. 2^{46}
- D. $(1/2)^{23}$

119 Nocturnal animals have retinas that contain

- A. a high percentage of rods to increase sensitivity to low light conditions
- B. a high percentage of cones so that nocturnal color vision can be improved in low light conditions
- C. an equal number of rods and cones so that vision can be optimized
- D. retinas with the photoreceptor layer present in the front of the eye to increase light sensitivity

120 The length of one complete turn of a DNA double helix is

- A. 34 Å
- B. 34 nm
- C. 3.4 Å
- D. 3.4 μm

ROUGH WORK

11. The brain of the guinea pig is shown in the figure below. The brain is divided into several parts. The cerebrum is the largest part of the brain and is responsible for most of the higher functions of the brain. The cerebellum is a smaller part of the brain that is responsible for coordination and balance. The brainstem is the part of the brain that connects the cerebrum and cerebellum to the spinal cord. The brainstem is divided into three parts: the midbrain, the pons, and the medulla oblongata. The medulla oblongata is the part of the brainstem that is continuous with the spinal cord. The medulla oblongata is responsible for many of the basic functions of the body, such as breathing, heart rate, and blood pressure. The medulla oblongata is also responsible for the control of the autonomic nervous system. The autonomic nervous system is the part of the nervous system that controls the internal organs and glands. The autonomic nervous system is divided into two parts: the sympathetic nervous system and the parasympathetic nervous system. The sympathetic nervous system is responsible for the fight or flight response, while the parasympathetic nervous system is responsible for the rest and digest response. The brain is a very complex organ and is the center of the nervous system. It is responsible for all of the higher functions of the body, such as thought, memory, and emotion. The brain is also responsible for the control of the autonomic nervous system. The brain is a very delicate organ and is very vulnerable to injury. It is important to take care of the brain and to avoid any activities that could cause brain injury.

ROUGH WORK